

Basalt FRP Rebar

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What is Basalt?

- ◆ Volcanic Rock – worldwide deposits
- ◆ Specific Gravity, Density & Weight same as Granite
- ◆ Natural Material – No Additives
- ◆ Quarry, Crush & Re-Melt (2700°F)
- ◆ Spin Process = Rockwool
- ◆ Drawing Process = Continuous Basalt Fiber (CBF)

Rockwool – Spin Process



CBF – Drawing Process



Continuous Basalt Fiber - CBF

- ◆ Drawn through Platinum-Rhodium die with 200-800+ orifices
- ◆ Each Fiber is 10-20 microns diameter
Hair = 40-120 Copy Paper = 100
- ◆ Coated with "sizing" for end use
- ◆ Grouped in strands called "tow"
- ◆ Wound on bobbin called "Roving"

Basalt Fiber Products

- ◆ Textiles – Fireproof Material
- ◆ Automotive – Brakes & Mufflers
- ◆ Aerospace – Alternate to Carbon
- ◆ Construction
 - Chopped fiber enhances performance
 - Grid alternate to WWF
 - Bars alternate to steel
 - Fabric for Epoxy Wraps

Chopped Basalt Fiber

- ◆ ½" to 2" lengths
- ◆ 3 to 5 lbs / cu.yd. dosage
- ◆ Early age – reduces cracking
- ◆ Final stage
 - Compressive up 10%
 - Tensile Increase
 - Can eliminate WWF



Basalt Grid



- ◆ Woven Strands
- ◆ Coating
 - Epoxy
 - Asphalt
- ◆ Alternate to WWF

Basalt FRP Rebar

- ◆ Same pultrusion process as Glass
- ◆ New Wet Lay-up Process
- ◆ Same types of resins as Glass
- ◆ Various kinds of deformations
- ◆ Higher Strength
- ◆ Higher Modulus
- ◆ Higher Strain

Basalt FRP Rebar



BFRP Rebar Properties

- ◆ Tensile = 116~174 ksi (800~1200 MPa)
 - Glass = 70~120 ksi (480~825 MPa)
 - Steel = 70~100 ksi (480~690 MPa)
- ◆ Modulus = $6.5 \sim 10.1 \times 10^3$ ksi (45-70 GPa)
 - Glass = $5.1 \sim 7.4 \times 10^3$ ksi (35~51 GPa)
 - Steel = 29×10^3 ksi (200 GPa)
- ◆ Strain = 2.37 ~ 3.09% (ultimate)
 - Steel = 0.14 ~ 0.25% (yield)

BFRP Rebar Sizes (sample)

<u>Size</u>	<u>Tensile (ksi)</u>	<u>Bar (kip)</u>	<u>Modulus (x10³ ksi)</u>
◆ 2.5mm	162.4	1.2	5,884
◆ 3mm	161.7	1.8	5,890
◆ 4mm	161.0	3.1	5,901
◆ 5mm	160.3	4.9	5,912
◆ 6mm (#2)	159.5	7.0	5,923
◆ 8mm	158.1	12.3	5,946
◆ 10mm (#3)	156.6	19.1	5,969
◆ 12mm (#4)	155.2	27.2	5,991
◆ 16mm (#5)	152.3	47.5	6,037
◆ 18mm	150.8	59.5	6,060
◆ 20mm (#6)	149.4	72.7	6,083
◆ 22mm (#7)	147.9	87.2	6,106
◆ 25mm (#8)	145.8	110.9	6,141

Thompson's Bridge



Thompson's Bridge

- ◆ **Route A509**
County Fermanagh
Northern Ireland, UK
- ◆ **Single Span = 105 feet (32m)**
- ◆ **Width = 26 feet (8m)**
- ◆ **Skew = 63°**
- ◆ **Integral Abutments**
- ◆ **Precast Prestressed U-Beams**
- ◆ **Precast Stay-in-Place Forms**



Thompson's Bridge

Deck Spans

4.59' between beams

5.25' over U-beams

Reinforcing

0.6% BFRP Bars

0.7% Steel Bars

Loading

40 ton on 11.8" dia. Plate
(15 Max Euro Wheel Load)



Thompson's Bridge

Test Results - Deflection

Span = 4.59' (1.4m)
0.012~0.019 in.
(0.30~0.48mm)
L/2917

Span = 5.25' (1.6m)
0.013~0.045 in.
(0.33~1.14mm)
L/1404

Steel = Up to Twice as much!



Thompson's Bridge

Test Results - Strain

Measured Ultimate BFRP Bar
0.671 (17037 $\mu\epsilon$)

Maximum Recorded Test
0.078 (1993 $\mu\epsilon$)

Max = 11.7% of Ultimate

Safety Factor = 8.5

Good recovery after test back
to service load values



Dr. Simon Grattan, Sengenica, Ltd.
Dr. Su Taylor, Queens University, Belfast

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Questions?